FIELD INSTALLABLE OPTICAL FIBER CONNECTOR

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0001] The present invention relates generally to optical fiber connectors and more particularly to optical fiber connectors adapted for field installation.

TECHNICAL BACKGROUND

[0002] Optical fibers are widely used in a variety of applications, including the telecommunications industry in which optical fibers are employed in a number of telephony and data transmission applications. Due, at least in part, to the extremely wide bandwidth and the low noise operation provided by optical fibers, the use of optical fibers and the variety of applications in which optical fibers are used are continuing to increase. For example, optical fibers no longer serve as merely a medium for long distance signal transmission, but are being increasingly routed directly to the home or, in some instances, directly to a desk or other work location.

[0003] With the ever increasing and varied use of optical fibers, it is apparent that efficient methods of coupling optical fibers, such as to other optical fibers, to a patch panel in a telephone central office or in an office building or to various remote terminals or pedestals, is required. However, in order to efficiently couple the signals transmitted by the respective optical fibers, an optical fiber connector must not significantly attenuate or alter the transmitted signals. In addition, the optical fiber connector must be relatively rugged and adapted to be connected and disconnected a number of times in order to accommodate changes in the optical fiber transmission path.

[0004] In order to provide the desired signal transmission characteristics, a number of optical fiber connectors have been developed which are mounted to the end portion of an optical fiber during a factory assembly process. By mounting the optical fiber connector to the optical fiber and/or optical fiber cable (hereinafter optical fiber) during an

assembly process at the factory, the assembly of the optical fiber connector can be standardized such that inconsistent assembly and other problems associated with the field installation of the connector are avoided.

[0005] However, the factory installation of fiber optic connectors is not altogether satisfactory for every application. In particular, the factory installation of fiber optic connectors does not customize the installation process to account for the myriad of design variations experienced in the field. For example, by installing fiber optic connectors to the end portion of an optical fiber at the factory, the length of the connectorized optical fiber is fixed, thus requiring excess length and coiling to insure sufficient length for all applications. In addition, in many instances it is desirable to cut a length of optical fiber into a plurality of shorter lengths of optical fiber, each of which must be individually connected, such as by an optical fiber connector, to another optical fiber or to a patch panel or other type of terminal. However, the respective lengths of the shorter optical fibers cannot generally be determined until the optical fibers are installed in the field. Thus, in this instance, the requisite optical fiber connectors cannot be mounted to the fibers at the factory prior to installation of the optical fiber. Still further, it is desirable in many instances to package and ship optical fiber prior to the installation of the fiber optic connectors since the fiber optic connectors generally have a greater diameter than the respective optical fiber, and may unnecessarily complicate the packaging and shipping of the optical fiber.

[0006] Consequently, several optical fiber connectors have been developed which can be mounted to the end portion of an optical fiber in the field once the particular application of the optical fiber has been determined. For example, U.S. Pat. No. 5,040,867 which issued August 20, 1991 to Michael de Jong et al. and which is assigned to the assignee of the present invention, discloses an optical fiber connector which is adapted for installation in the field. One commercial embodiment of the optical fiber connector of U.S. Pat. No. 5,040,867 is the Camlite® connector which is manufactured and distributed by Corning Cable Systems LLC of Hickory, North Carolina.

[0007] The Camlite® connector includes a lengthwise extending ferrule defining a longitudinal bore therethrough attached to a V- groove splice with a cam member for

securing a fiber in the splice. A short length of optical fiber, typically termed an optical fiber stub, is disposed in the bore of the ferrule and extends into the V-groove splice. In the field, the end portion of an optical fiber, typically termed the field fiber, to which the optical fiber connector is to be connected, can be inserted in the V-groove splice from the end opposite the ferrule. Due to the precise alignment of the longitudinally extending V-groove within the Camlite® connector, the end portion of the field fiber is aligned with the optical fiber stub and thereafter held in place by activating the cam member.

[0008] The Camlite® connector can also include a crimp tube mounted to the end of the V-groove opposite the ferrule such that the field fiber extends therethrough. By compressing the crimp tube radially inward so as to contact the field fiber cable, the field fiber is fixed in position relative to the ferrule and the aligned optical fiber stub. The ferrule of the Camlite® connector can, in turn, be disposed within any of the standard connector housings. For example, the ferrule of the Camlite® connector is compatible with and can be mounted within an FC, ST or SC connector housing. The resulting Camlite® connector can then be connected, such as with an adapter or coupling sleeve, to the end portion of another optical fiber which also has an appropriate connector mounted to an end portion thereof. Alternatively, the resulting Camlite® connector can be connected to a patch panel, remote terminal or pedestal.

[0009] While the Camlite® connector is a great advance in the art, the Camlite® connector employs a cam member utilizing axial movement to establish a splice between the field fiber and the stub fiber. This may result in compressing together the abutting end faces of the optical fibers and potentially damaging the end faces. Moreover, The Camlite® connector, as with other field installable connectors, does not include a feature for readily and visually determining that an acceptable splice has been made.

SUMMARY OF THE INVENTION

[0010] A broad aspect of the invention includes a housing having an inner surface defining a cavity extending longitudinally therethrough and a spring element seat disposed therein, the housing also defining a forward opening in communication with the cavity and a rearward opening in communication with the cavity. The connector also

comprises a spring element inserted into the cavity through the forward opening of the housing and a ferrule holder inserted into the cavity through the rearward opening of the housing. A spring element retainer is disposed about a forward end of the ferrule holder, and the spring element is disposed between the spring element seat and the spring element retainer thereby urging the ferrule holder forward with a predetermined spring force. Preferably, the predetermined spring force is greater than about 1lb; more preferably between about 1 and 1.5 lbs; and most preferably between about 1.1 and 1.4 lbs. The optical fiber connector comprises a ferrule disposed within the ferrule holder, and an optical fiber stub disposed within the ferrule. The optical fiber connector according to an embodiment of the invention also comprises a view port for providing a visual indication of the quality of a splice between the optical fiber stub and a second optical fiber within the connector.

[0011] In another broad aspect of the invention an optical fiber connector is provided which includes a housing having an inner surface defining a cavity extending longitudinally and a spring element seat therein, the housing also defining a rearward opening in communication with the cavity and a forward opening in communication with the cavity. The optical fiber connector according to an embodiment of the invention further comprises a ferrule having first and second ends with a passageway disposed axially therebetween, and an optical fiber stub disposed within the ferrule passageway. A ferrule holder extends longitudinally between opposing first and second ends and defines a passageway extending longitudinally therebetween. The ferrule holder first end is inserted through the housing rearward opening and extends beyond the spring element seat. The ferrule holder is configured to hold the ferrule and is slidable longitudinally within the housing. A spring element retainer is disposed at the first end of the ferrule holder. A first and second opposed splice member are disposed within the ferrule holder, each splice member extending longitudinally from a first end proximate the second end of the ferrule to an opposite second end. One of the splice members includes a longitudinal fiber aligning groove wherein the optical fiber stub extends between the opposed splice members in the groove and terminates at a position intermediate the first and second ends of the splice members. A cam member having a first end, a second end

and a passageway extending longitudinally therebetween is disposed about the ferrule holder. A spring element is disposed between the spring element seat and the spring element retainer, the spring element urging the ferrule holder forward with a predetermined spring force. The ferrule holder preferably comprises a stop disposed at an intermediate position between the ferrule holder first and second ends and configured to cooperate with the housing rearward opening. Preferably, the predetermined spring force is greater than about 1 lb; more preferably between about 1 lb. and 1.5 lbs; and most preferably between about 1.1 and 1.4 lbs. The optical fiber connector preferably comprises a port for providing a visual indication of the quality of a splice between the optical fiber stub and a field fiber.

[0012] In still another aspect of the invention, an optical fiber connector having a view port for providing a visual indication of the quality of a splice between a first and second optical fiber within the connector is disclosed.

[0013] In yet another broad aspect of the invention, a method of determining the quality of a splice between first and second optical fibers within an optical fiber connector is proposed, the method comprising passing a visible light through at least one of the optical fibers and viewing a view port on the connector for visual indication of the quality of a splice between the first and second optical fibers. Preferably, the visible light is a laser light or light from a light emitting diode (LED). The visual indication preferably comprises either the absence of visible light or the presence of light within the view port.

[0014] Although the optical fiber connector disclosed herein is generally described as an LC connector, it should be understood that the choice of an LC connector is for illustrative purposes only, and that the principals as described herein may be applied to other optical fiber connectors as well, such as SC, ST and FC connectors.

[0015] Additional features and advantages of the invention will be set forth in the detailed description which follows, and in part will be readily apparent to those skilled in the art from that description or recognized by practicing the invention as described herein, including the detailed description which follows, the claims, as well as the appended drawings.

[0016] It is to be understood that both the foregoing general description and the following detailed description present embodiments of the invention, and are intended to provide an overview or framework for understanding the nature and character of the invention as it is claimed. The accompanying drawings are included to provide a further understanding of the invention, and are incorporated into and constitute a part of this specification. The drawings illustrate various embodiments of the invention, and together with the description serve to explain the principles and operations of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. 1 is an exploded view of a fiber optic connector according to an embodiment of the present invention.

[0018] FIG. 2 is an end view of the rearward end of the connector housing of FIG. 1 showing the alignment key.

[0019] FIG. 3 is a longitudinal cross section of the connector housing of FIG. 1 taken along the line 3-3 in FIG. 2.

[0020] FIG. 4 is a perspective view of the connector housing of FIG. 1showing the latching arm and latching lugs.

[0021] FIG. 5 is an end view of the rearward end of the ferrule holder of FIG. 1.

[0022] FIG. 6 is a longitudinal cross section of the ferrule holder of FIG. 1 taken along the line 6-6 in FIG. 5.

[0023] FIG. 7 is a longitudinal cross section of the ferrule and the optical fiber stub of FIG. 1.

[0024] FIG. 8 is a perspective view of the ferrule holder of FIG. 1 showing the view port for providing a visual indication of the quality of a splice between the optical fiber stub and the field fiber, and showing the L-shaped groove for guiding the cam member.

[0025] FIG. 9 is an end view of the lead in tube of FIG. 1.

[0026] FIG. 10 is a perspective view of the lead in tube of FIG. 1.

[0027] FIG. 11 is a longitudinal cross section of the lead in tube of FIG. 1 taken along the line 11-11 in FIG. 9.

[0028] FIG. 12 is a longitudinal cross section of the lead in tube of FIG. 1 taken along the line 12-12 in FIG. 9.

[0029] FIG. 13 is a perspective view of the first and second splice members of FIG. 1 showing the groove for aligning the optical fiber stub and the field fiber.

[0030] FIG. 14 is a longitudinal cross section of the fiber optic connector of FIG. 1 shown in the fully assembled configuration.

[0031] FIG. 15 is an end view of the cam member of FIG. 1 showing the major axis and the minor axis.

[0032] FIG. 16 is a longitudinal cross section of the cam member of FIG. 1 taken along the line 16-16 in FIG. 15.

[0033] FIG. 17 is a perspective view of the cam member of FIG 1.

[0034] FIG. 18 is a detailed view of the L-shaped groove of the ferule holder shown in FIG. 8 illustrating the ridges for retaining the inwardly extending projection of the cam member.

[0035] FIG. 19 is an end view of the splice members positioned within the ferrule holder with the cam member positioned on the ferrule holder and the keel portion of the second splice member aligned along the major axis of the cam member.

[0036] FIG. 20 is an end view of the splice members positioned within the ferrule holder with the cam member positioned on the ferrule holder and the keel portion of the second splice member aligned along the minor axis of the cam member.

[0037] FIG. 21 is a partial longitudinal cross section of the first end of the ferrule holder showing an exemplary attachment of the spring element retainer with a screw thread.

[0038] FIG. 22 is a partial longitudinal cross section of the first end of the ferrule holder showing an exemplary attachment of the spring element retainer with a ridge and groove.

[0039] FIG. 23 is a partial longitudinal cross section of the first end of the ferrule holder showing an exemplary attachment of the spring element retainer with a ridge and groove in an alternative configuration.

[0040] FIG. 24 is a perspective view of the trigger member of FIG. 1.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0041] Detailed references will now be made to the drawings in which examples embodying this invention are shown. The drawings and detailed description provide a full and detailed written description of the invention, and of the manner and process of making and using it, so as to enable one skilled in the pertinent art to make and use it, as well as the best mode of carrying out the invention. However, the examples set forth in the drawings and detailed description are provided by way of explanation of the invention and not meant as a limitation of the invention. This invention thus includes any modifications and variations of the following examples as come within the scope of the appended claims and their equivalents.

[0042] The detailed description uses numerical and letter designations to refer to features in the drawings. Like or similar designations in the drawings and description have been used to refer to like or similar parts of the invention.

[0043] As embodied in FIG. 1, a fiber optic connector **10** for connecting an optical fiber cable **12** to a receptacle (not shown), such as another connector, a connector adapter or other optical device, is provided.

[0044] With more particular reference to the Figures, connector **10** is attached to field fiber **14** of optical fiber cable **12**. Field fiber **14** typically has a glass diameter of about 125 μm. Typically, field fiber **14** also comprises one or more coatings disposed about the optical fiber. The one or more coatings may have various diameters, including diameters from about 245 μm to 900 μm for a buffered optical fiber, without departing from the scope of the present invention. Connector **10** includes connector housing **16**, ferrule **18**, ferrule holder **20**, spring element retainer **22**, spring element **24**, splice members **26, 28**, and cam member **30**.

[0045] As shown in greater detail in FIGS. 2 and 3, connector housing **16** has an inner surface **32** defining cavity **34** which extends longitudinally within housing **16**. Housing **16** further includes a forward opening **36** in communication with cavity **34** and a rearward opening **38** also in communication with cavity **34**. Rearward opening **38** is configured to receive ferrule holder **20** (FIG. 1). Inner surface **32** of cavity **34** further

defines a spring element seat **40**, the forward face **42** thereof providing a surface against which spring element **24** (FIG. 1) may abut. Spring element seat **40** is generally located proximate to rearward opening **38**. The rearward face **44** of spring element seat **40** serves as a positive stop to limit the forward movement of ferrule holder **20** into housing cavity **34**. Inner surface **32** includes key **46** extending into cavity **34** at rearward opening **38**. Key **46** may be more clearly seen in FIG. 2 showing a view of housing **16** looking forward toward forward opening **36** from rearward opening **38**. Preferably key **46** extends between the rearward face **44** of spring element seat **40** and opening **38**. Preferably, that portion of cavity **34** which extends forward of spring element seat **40** to forward opening **36** has a circular cross section in a plane orthagonal to longitudinal axis **48**, as best shown in FIG. 2. Preferably, that portion of cavity **34** which extends rearward of spring element seat **40** to rearward opening **38** has a cross sectional shape in a plane orthogonal to longitudinal axis **48** which is adapted to receive the cross sectional shape of at least a portion of ferrule holder **20**. Preferably, that portion of cavity **34** which extends rearward of spring element seat **40** to rearward opening **38** has a polygonal cross section in a plane orthagonal with longitudinal axis **48** of housing **16**.

[0046] Housing **16** also includes latching arm **50** and, as more clearly seen in FIG. 4, opposing latching lugs **52, 54** extending from housing **16** for latching connector **10** in place, such as, for example, an adapter adapted to receive connector **10**. Preferably, latching arm **50** is of a sufficient resiliency to allow latching arm **50** to be depressed and to return to its un-depressed position when latching arm **50** is released. Preferably, housing **16**, latching arm **50**, latching lugs **52, 54**, spring element seat **40** and key **46** are comprised of a suitable plastic material and are molded in one piece therefrom.

[0047] As illustrated in FIGS. 5 and 6, ferrule holder **20** extends longitudinally between first end **56** and second end **58**, and defines a longitudinally extending passageway **60**. Passageway **60** proximate first end **56** of ferrule holder **20** is sized to receive ferrule **18**, which may be made of any suitable, wear-resistant material such as ceramic, glass, metal, glass-reinforced epoxy or a polymer plastic. Ferrule **18**, shown in FIG. 7, has a first end **62** and a second end **64** and defines bore **66** extending axially therethrough. Optical fiber stub **68** is disposed in bore **66** such that second end **69** of optical fiber stub **68** extends

beyond second end **64** of ferrule **18**. Preferably, second end **69** of optical fiber stub **18** extends at least about 5 mm beyond second end **64** of ferrule **18**; more preferably at least about 10 mm. Optical fiber stub **68** is preferably secured in bore **66** with an adhesive such as an epoxy adhesive. The second end **69** of optical fiber stub **68** is preferably cleaved with a good finish, the cleave angle being preferably less than about one degree. The first end **69** of optical fiber stub **68** is preferably polished to facilitate optical transmission therethrough.

[0048] Returning to FIG. 6, ferrule holder **20** further defines cavity **70** in communication with passageway **60** to accommodate splice members **26** and **28** (FIG. 1). Ferrule holder **20** includes a shoulder **72**, or stop, on outside surface **74** of ferrule holder **20** which is configured to be received into rearward opening **38** of connector housing **16**. A groove **76** extending longitudinally along at least a portion of stop **72** (more clearly seen in FIG. 8) is configured to slidably engage with key **46** to provide for the correct orientation of ferrule holder **20** within housing **16**. Preferably, ferrule holder **20** also defines view port **78** extending from outside surface **72** into cavity **70** proximate the location of the mechanical abutment between stub fiber **68** and field fiber **14**. During operation of connector **10**, field fiber **14** and stub fiber **68** are abutted proximate view port **78** and a visible light, such as that from a HeNe laser or an LED, for example, is guided through at least one of the field fiber **14** or stub fiber **68**. If an incorrect abutment is obtained, light guided by optical fiber stub **68** or field fiber **14** will be scattered at the opposing end face and will be visible through view port **78**. When an acceptable abutment, or splice, is obtained, the light will be substantially guided between optical fiber stub **68** and field fiber **14**, with little scattering at the abutment thereof, and light from the laser or LED will no longer be visible through view port **78**. Therefore, view port **78** provides a visual indication of an acceptable mechanical splice (abutment) between the optical fiber stub **68** and the field fiber **14**. If the splice is unacceptable, the laser or LED light will not be visible through view port **78**. View port **78** may also be used as an access point for injecting an optical coupling material or refractive index matching gel into cavity **70** to improve the optical coupling between the optical fiber stub **48** and field fiber **14**.

[0049] Ferrule holder **20** also includes a slot, or window **80** extending between outside surface **74** and cavity **70** to accommodate a portion of lower splice component **28**. Window **80** is generally located opposite view port **78**. Second end **58** of ferrule holder **20** is adapted to receive a lead in tube **84**, illustrated in FIGS. 9-12, for guiding field fiber **14** into cavity **70** between splice members **26, 28**. Preferably, inside surface **86** of cavity **70** defines an axial groove **88** for receiving key **90** located on outside surface **92** of lead in tube **84**. When lead in tube **84** is inserted into second end **58** of ferrule holder **20**, groove **88** slidably engages with key **90** to prevent rotation of lead in tube **84** within ferrule holder **20**. Lead in tube **84** defines a passageway **94** (FIGS. 11 and 12) extending axially between a first end **96** and a second end **98** of lead in tube **84** for accommodating field fiber **14**. Lead in tube **84** may be secured within ferrule holder **20** with an adhesive, such as, for example, an epoxy adhesive. Alternatively, lead in tube **84** could be press fit within ferrule holder **20**, or lead in tube **84** may be secured within ferrule holder **20** by cooperative retaining elements similar to those shown in FIGS. 21-23 and described infra. Preferably, second end **98** of passageway **94** is sized to accommodate a crimp tube **132** FIG. 1). Preferably, a portion of passageway **94** proximate first end **96** has a generally conical shape for guiding field fiber **14** through opening **100** at first end **96** of lead in tube **84**.

[0050] Splice members **26** and **28** are inserted into cavity **70** of ferrule holder **20** through second end **58** proximate view port **78** and window **80**. First splice member **26** is generally adjacent view port **78**, while second splice member **28** is generally adjacent window **80**. As best depicted by FIG. 13, first splice member **26** is configured with a flat face **102** opposing second splice member **28**. Second splice member **28** comprises a projection, or keel portion **104** which protrudes through window **80** when splice member **28** is inserted into cavity **70** of ferrule holder **20**. A channel **81** extending from second end **58** of ferrule holder **20** to window **80** and shown in FIGS. 5 and 6 guides keel portion **104** to window **80**, thereby facilitating the insertion of second splice member **28** into cavity **70** through second end **58**, and the further insertion of keel **104** through window **80**. On side **106** opposite keel portion **104** and opposing first splice component **26**, second splice member **28** includes a groove **108** extending longitudinally along the length

of second splice member **28**. Although groove **108** as shown in FIG. 13 is generally V-shaped, groove **108** could be any other shape that supports optical fiber stub **68**, such as, for example, a U-shaped groove. Alternatively, groove **108** could be formed in the opposing face of first splice component **26** and a flat face could be formed on the opposing face of second splice component **28**. Splice members **26, 28** are prevented from moving forward within cavity **70** in ferrule holder **20** by shoulder **110** adjacent the point where cavity **70** is in communication with passageway **60**. When ferrule **18** containing optical fiber stub **68** is positioned within first end **56** of ferrule holder **20**, the end of optical fiber stub **68** projecting from ferrule **18** is received by groove **108** and lies between first and second splice members **26** and **28** at a generally intermediate position. When lead in tube **84** is inserted in second end **58** of ferrule holder **20**, splice members **26, 28** are prevented from moving rearward within cavity **70** by the presence of lead in tube **84**. Thus, splice members **26** and **28** are generally prevented from axial movement within cavity **70** by shoulder **110** and lead in tube **84**.

[0051] Cam member **30** is mounted about ferrule holder **20** in an initial position generally proximate splice members **26, 28** as shown in FIG. 9. As illustrated in FIGS. 15-17, cam member **30** defines passageway **112** extending longitudinally between first end **118** and second end **120** that is sized to receive and therefore be mounted upon ferrule holder **20**. In order to actuate splice members **26, 28**, a portion of passageway **112** defined by cam member **30** is preferably noncircular and comprises a major axis **114** and a minor axis **116** as illustrated in FIG. 15. As best shown in FIG. 16, the portion of cam member **30** extending forward of shoulder **121** to end **118** is noncircular and defines major axis **114** and minor axis **116**. That portion of cam member **30** extending rearward of shoulder **121** to end **120** is generally circular and facilitates engagement of cam member **30** with ferrule holder **20**. Thus, shoulder **121** denotes the transition from the circular portion of passageway **112** and the noncircular portion of passageway **112**. As shown by FIG. 16 and as evidenced by the thinner sidewall immediately adjacent the major axis **114** of cam member **30** at end **118**, the portions of passageway **112** adjacent major axis **114** have a smaller radius than the radius of those portions of passageway **112** immediately adjacent minor axis **116**. Moreover, passageway **112** is defined by cam member **30** such that the

smaller radius of passageway **112** immediately adjacent major axis **114** transitions smoothly into the larger radius of passageway **112** immediately adjacent minor axis **116**. Preferably, cam member **30** also includes an outside surface at end **120** adapted to cooperate with a tool (not shown) for rotating cam member **30** about ferrule holder **20**. In the advantageous embodiment depicted in FIGS. 15-17, cam member **30** preferably comprises a first and second end **118**, **120** separated by a barrel **122**. The outside surface of cam member **30** at second end **120** may be formed as a polygon such that the outside surface of end **120** may cooperatively engage with a tool, such as a wrench, for example, for rotating cam member **30** about ferrule holder **20**. However, it should be understood that the outside surface of end **120** may take on other shapes, such as a notched circular shape, which may cooperate with a complementary engaging surface or surfaces of an actuating tool. First end **118** is preferably formed to a shape and size which corresponds to the shape and size of the rearward portion of housing **16**. Cam member **30** preferably includes an indicator element, such as groove **123** best shown in FIG. 17 at end **120**, to indicate the rotational position of cam member **30**, and thus. the condition of splice members **26**, **28** (i.e. actuated or un-actuated). For example, if visual indicator **123** is aligned with latch **50**, splice members **26**, **28** are actuated.

[0052] As first illustrated in FIG. 19, cam member **30** of this advantageous embodiment is mounted upon ferrule holder **20** such that the noncircular portion of passageway **112** is generally disposed within ferrule holder **20** and exposed keel portion **104** of second splice member **28** is aligned with major axis **114** of passageway **112**. As a result, cam member **30** can be readily mounted on ferrule holder **20** while splice members **26** and **28** remain un-actuated. As next shown in FIG. 20, once cam member **30** has been mounted upon ferrule holder **20**, however, cam member **30** can be rotated relative to ferrule holder **20** from the first un-actuated position to a second actuated position so as to move the exposed keel portion **104** of second splice member **28** from a position along major axis **114** of passageway **112** to a position along minor axis **116** of passageway **112**. Due to the smaller dimensions of passageway **112** along minor axis **116**, cam member **30** operably contacts exposed keel portion **104** of second splice member **28** following rotation of cam member **30** relative to ferrule holder **20**. As a result of this contact, cam

member **30** actuates splice members **26, 28**, such as by urging the splice members **26, 28** toward one another, so as to mechanically splice optical fiber stub **68** and field fiber **14** therebetween.

[0053] As best shown in FIGS. 15 and 16, cam member **30** of one advantageous embodiment of the present invention includes an inwardly extending projection **124**. While the inwardly extending projection **124** is adjacent one end of cam member **30** in the illustrated embodiment, the inwardly extending projection **124** can be positioned at other points along the lengthwise extending passageway **112**, if so desired. As shown in FIG. 8, the outer surface **72** of ferrule holder **20** of this advantageous embodiment also preferably defines a groove **126** for receiving the inwardly extending projection **124**. By confining the inwardly extending projection **124** within groove **126**, ferrule holder **20** can guide cam member **30** as cam member **30** is initially mounted upon ferrule holder **20**, i.e. slid lengthwise relative to ferrule holder **20**, as cam member **30** is subsequently rotated relative to ferrule holder **20** from the first, un-actuated position to the second, actuated position. Preferably, cam member **30** is formed from a transparent or translucent material such that light which may emit from view port **78** when testing connector **10** for proper abutment (splice quality) of stub fiber **68** and field fiber **14** will be visible through cam member **30**.

[0054] In the illustrated embodiment, the groove **126** defined by ferrule holder **20** is generally L-shaped. As such, groove **126** includes a first section **128** that extends lengthwise along a portion of ferrule holder **20** from the second end **58** of ferrule holder **20** to a medial portion of ferrule holder **20**. In addition, groove **126** includes a second section **130** that extends circumferentially about a portion, such as one-quarter, of ferrule holder **20**. As such, the inwardly extending projection **124** of cam member **30** is moved through the first section **128** of groove **126** as cam member **30** is slid lengthwise relative to ferrule holder **20** as cam member **30** is mounted upon ferrule holder **20**. Thereafter, the inwardly extending projection **124** of cam member **30** is moved through the second section **130** of groove **126** as cam member **30** is rotated relative to ferrule holder **20**. First and second sections **128, 130** of groove **126** of this embodiment are preferably orthogonal and intersect in the medial portion of ferrule holder **20** to permit cam member **30** to be

rotated relative to ferrule holder **20** once cam member **30** has been fully mounted upon ferrule holder **20**. As best illustrated by the detailed view in FIG. 18, second section **130** of groove **126** also includes ridge **131** extending across the width of second section **130** for retaining cam member **30** in place after cam **30** has been rotated relative to ferrule holder **20** to the second, actuated position. As inwardly extending projection **124** is moved along second section **130** of groove **126**, inwardly extending projection **124** is "snapped" over ridge **131**, thereby interferingly restraining cam member **30** from being inadvertently removed from ferrule holder **20**.

[0055] As described supra, cam member **30** is in the first un-actuated position as cam member **30** is mounted upon ferrule holder **20** by moving the inwardly extending projection **124** through the first section **128** of groove **126**. As also described supra, cam member **30** transitions from the first, un-actuated position to the second, actuated position as cam member **30** is rotated relative to ferrule holder **20** by moving the inwardly extending projection **124** through the second section **130** of groove **126**. In the embodiment in which passageway **112** defined by cam member **30** includes a major axis **114** and a minor axis **116**, cam member **30** and ferrule holder **20** are preferably designed such that exposed keel portion **104** of second splice member **28** is aligned with major axis **114** of passageway **112** of cam member **30** as inwardly extending projection **124** of cam member **30** is moved through first section **128** of groove **126**. Correspondingly, cam member **30** and ferrule holder **20** of this advantageous embodiment are also preferably designed such that the exposed keel portion **104** of second splice member **28** is moved along the inside surface of cam member **30** from alignment with the major axis **114** of passageway **112** to alignment with the minor axis **116** of passageway **112** as the inwardly extending projection **124** is moved along through the second section **130** of groove **126**. By engaging exposed keel portion **104** of second splice member **28** with the inside surface of cam member **30** along the minor axis **116** of passageway **112**, splice components **26**, **28** are actuated, such as by urging first and second splice members **26**, **28** toward one another, so as to mechanically splice optical fiber stub **68** and field fiber **14** as described above.

[0056] By confining the inwardly extending projection **124** of cam member **30** to the generally L-shaped groove **126**, the fiber optic connector **10** of this advantageous embodiment of the present invention insures that cam member **30** is fully mounted upon ferrule holder **20** prior to actuating splice members **26, 28** by rotating cam member **30** relative to ferrule holder **20**, thereby providing complete or full actuation of splice members **26, 28**. In addition, fiber optic connector **10** of this advantageous embodiment prevents cam member **30** from being removed from ferrule holder **20** without first being moved to an un-actuated position by rotating cam member **30** in the opposite direction relative to ferrule holder **20** so as to move the inwardly extending projection **124** from second section **130** of groove **126** in which splice members **26, 28** are actuated to first section **128** of groove **126** in which splice members **26, 28** are un-actuated. Ridge **131**, in cooperation with inwardly extending projection **124**, prevents inadvertent removal of cam member **30**. Thus, fiber optic connector **10** of this advantageous embodiment prevents inadvertent damage to the components of the fiber optic connector which could otherwise possibly be incurred by removing cam member **30** from ferrule holder **20** while in the actuated position. Once splice members **26, 28** have been actuated, such as by mounting cam member **30** upon the ferrule holder **20** and thereafter rotating cam member **30** relative to ferrule holder **20** the remaining components of the fiber optical connector may be assembled.

[0057] As shown in FIGS. 1 and 14, fiber optic connector **10** includes crimp tube **132** which is mounted within the rearward end of lead in tube **84**. Crimp tube **132** may be formed from any material suitable for the purpose, including copper, stainless steel or brass. To insert field fiber **14** into crimp tube **132**, a portion of coating which may surround field fiber **14** is removed to expose the bare glass of field fiber **14**. Enough coating material is removed from field fiber **14** such that field fiber **14** may extend within connector **10** to abut with optical fiber stub **68** between splice members **26** and **28**. When field fiber **14** has been inserted into crimp tube **132**, the coated portion of field fiber **14** may be securely engaged by crimp tube **132** by crimping crimp tube **132** about the coated portion of field fiber **14**.

[0058] Also as shown in FIGS. 1 and 14, fiber optic connector **10** may include annular crimp band **134** which is mounted upon the rearward end **58** of ferrule holder **20** proximate cam member **30**. Crimp band **134** may be formed from any material suitable for the purpose, including copper, stainless steel or brass. In embodiments in which field fiber **14** is associated with strength members **136**, such as the filamentary strength members of fiber optic cable **12** as shown in FIG. 1, strength members **136** can be positioned between crimp band **134** and ferrule holder **20** such that strength members **136** can be securely engaged by crimping crimp band **134** about ferrule holder **20** as known by those skilled in the art. The strength members of fiber optical cable **12** may comprise, for example, an aramid filament or yarn. Thereafter, boot **138** which has previously been mounted on field fiber **14** can be mounted over crimp band **134** so as to provide strain relief to field fiber **14**.

[0059] As illustrated in FIG. 1 and 14, ferrule holder **20** is inserted into the rearward opening **38** of housing **16** such that first end **56** of ferrule holder **20**, and ferrule **18**, extend forward beyond spring element seat **40**. Spring element **24** is positioned over first end **56** of ferrule holder **20** and compressed between the forward face **42** of spring element seat **40** and spring element retainer **22** to a predetermined spring force, spring element retainer **22** being engaged with first end **56** of ferrule holder **20**. Thus, ferrule holder **20**, and ferrule **18**, are allowed to translate axially, or piston, within housing **16**. Spring element retainer **22** may be engaged with first end **56** of ferrule holder **20** by any suitable method known in the art. As best shown in FIGS. 6 and 8, ferrule holder **20** is formed with screw threads **140** located proximate end **56**. As best depicted in FIG. 21, corresponding screw threads on the inside surface of spring element retainer **22** are configured to engage with screw threads **140** on ferrule holder **20** and allow spring element retainer **22** to be removably fastened to end **56** of ferrule holder **20** by screwing spring element retainer **22** to end **56** of ferrule holder **20**. Alternatively, end **56** and spring element retainer **22** may be designed to allow spring element retainer **22** to be snap fit to ferrule holder **20** at end **56**. For example, as shown in FIGS. 22 and 23, a groove **139** (FIG. 23) may be formed about a circumference of ferrule holder **20** proximate end **56**. A corresponding ridge 129 (FIG. 22) formed about the inside circumference of

spring retainer **22** is configured to engage with groove **139**. Spring element retainer **22** may then be snapped into place over end **56** of ferrule holder **20**. Alternatively, a groove may be formed about the inside circumference of spring element retainer **22** and a corresponding ridge nay be formed about ferrule holder **20** proximate end **56**.

[0060] Spring element **24** is configured such that spring element **24** is fully compressed before stop **72** of ferrule holder **20** is completely removed from housing **16**, thus limiting the longitudinal movement of ferrule holder **20** within housing **16**. When connector **10** has been assembled, spring element **24** preferably exerts a spring force between about 1 and 1.5 lbs against spring retainer **22**, more preferably between about 1.1 and 1.4 lbs.

[0061] According to one embodiment of the invention, and as broadly shown in FIG. 24, a trigger member **142** is removably attached to cam member **30**. Trigger member **142** includes a first element **144** and a second element **146**. Trigger member **142** is removably attached to cam member **30** via first element **144**. First element **144** preferably defines a longitudinally-extending opening **148** configured for receiving cam barrel **122** (FIG. 17) and permitting trigger member **142** to be snapped over cam member **30** to thereby attach trigger member **142** to cam member **30**. More particularly, opening **148** is configured for permitting trigger member **142** to be radially snapped onto cam barrel **122**. Accordingly, a slot **150** is provided in first element **144**. Slot **150** should be wide enough to allow barrel **122** to pass though the slot. First member **144** may thus be substantially C-shaped to snugly fit on barrel **122** of cam member **30**. Although not illustrated, if barrel **122** was a shape other than cylindrical (e.g., square, rectangular, etc., in cross-section), then trigger member **142** would have a corresponding configuration.

[0062] Mating attachment elements are provided respectively on cam member **30** and first element **144** for releasably attaching and axially securing first element **144** to the housing. Preferably, the mating attachment elements comprise snap members **152** on trigger member **142** and grooves **153** in cam member **30**. The locations of snap members **152** and grooves **153** could be switched. Snap members **152** may include chamfered edges **154** to allow trigger member **142** to be more easily snapped over cam member **30**. The mating attachment elements may alternately have other complimentary shapes, such as ridges, dimples, arcs, spherical sections, etc., within the scope of the inve

spring retainer **22** is configured to engage with groove **139**. Spring element retainer **22** may then be snapped into place over end **56** of ferrule holder **20**. Alternatively, a groove may be formed about the inside circumference of spring element retainer **22** and a corresponding ridge nay be formed about ferrule holder **20** proximate end **56**.

[0060] Spring element **24** is configured such that spring element **24** is fully compressed before stop **72** of ferrule holder **20** is completely removed from housing **16**, thus limiting the longitudinal movement of ferrule holder **20** within housing **16**. When connector **10** has been assembled, spring element **24** preferably exerts a spring force between about 1 and 1.5 lbs against spring retainer **22**, more preferably between about 1.1 and 1.4 lbs.

[0061] According to one embodiment of the invention, and as broadly shown in FIG. 24, a trigger member **142** is removably attached to cam member **30**. Trigger member **142** includes a first element **144** and a second element **146**. Trigger member **142** is removably attached to cam member **30** via first element **144**. First element **144** preferably defines a longitudinally-extending opening **148** configured for receiving cam barrel **122** (FIG. 17) and permitting trigger member **142** to be snapped over cam member **30** to thereby attach trigger member **142** to cam member **30**. More particularly, opening **148** is configured for permitting trigger member **142** to be radially snapped onto cam barrel **122**. Accordingly, a slot **150** is provided in first element **144**. Slot **150** should be wide enough to allow barrel **122** to pass though the slot. First member **144** may thus be substantially C-shaped to snugly fit on barrel **122** of cam member **30**. Although not illustrated, if barrel **122** was a shape other than cylindrical (e.g., square, rectangular, etc., in cross-section), then trigger member **142** would have a corresponding configuration.

[0062] Mating attachment elements are provided respectively on cam member **30** and first element **144** for releasably attaching and axially securing first element **144** to the housing. Preferably, the mating attachment elements comprise snap members **152** on trigger member **142** and grooves **153** in cam member **30**. The locations of snap members **152** and grooves **153** could be switched. Snap members **152** may include chamfered edges **154** to allow trigger member **142** to be more easily snapped over cam member **30**. The mating attachment elements may alternately have other complimentary shapes, such as ridges, dimples, arcs, spherical sections, etc., within the scope of the invention.

[0063] Mating alignment elements are also provided for rotationally securing first element **144** relative to cam member **30**. The alignment elements may comprise any variety of non-circumferential surfaces that interferingly prevent substantial rotation of trigger member **30** relative to cam member **30**. The alignment elements may comprise for example, planar surfaces **156** and **158**, as shown in FIGS. 17 and 24, that contact each other when trigger member **142** is attached to cam member **30**. As shown, alignment elements **158** are on cam member **30** and alignment elements **156** are on first element **144** of trigger member **30**. Alternately, the alignment elements may comprise planar surfaces **160** at the ends of snap members **152** and corresponding planar surfaces at the bottom of grooves **153**. Also, the alignment elements could have shapes other than planar, such as oblong, oval, irregular, etc., and be within the scope of the invention. When the alignment elements are aligned, second member **146** is also aligned with latch **50** (unless trigger member **142** has been installed upside down). If desired, the attachment elements and alignment elements could be configured so that inadvertent misaligned attachment of trigger member **142** to cam member **30** is difficult or impossible, for example by making the attachment or alignment elements non-symmetrical or irregular in some way.

[0064] Second element **146** of trigger member **142** has a proximal end **162** attached to first element **144** and a distal end **164** extending from the first element. Second element **146** provides at least two functions. First, second element **146** is pivotable as is latch **50** and engages the latch to pivot the latch downward. The engagement moves distal end **166** (FIG. 3) of latch **50** downward to selectably release housing **16** from a receptacle. Second element **146** has a contoured surface **170** for contacting tip **172** (FIG. 3) of latch **50** and assisting in pivoting latch **50** downward when second element **146** is depressed. Second element **146** thus comprises a trigger element which releases latch **50** when the trigger element is depressed. The second function provided is that if cable **12** is pulled backwardly, second element **146** reduces the possibility of latch **50** snagging on other cables, corners, or other fixtures along the routing path, as the second element extends at an acute angle toward and beyond tip **172** of latch **50**. Preferably first and second elements **144, 146** are comprised of a suitable plastic material and are molded in one piece therefrom.

[0065] When ferrule holder **20** has been assembled into housing **16** and cam member **30** has been fully mounted onto ferrule holder **20**, trigger member **142** may preferably be mounted onto cam member **30** such that snap members **152** may engage with corresponding recesses, or grooves **153** on cam member **30**. The engagement of snap members **152** with grooves **153** prevent trigger member **142** from rotating on cam member **30** and maintain second trigger member **144** in alignment with latching arm **50** when cam member **30** has been rotated into the second, actuated position.

[0066] Field assembly of the optical fiber connector according to the present invention comprises inserting a second optical fiber, such as field fiber **14** into the rearward opening of lead in tube **84** until field fiber **14** is abutted to optical fiber stub **68**. Preferably, the end of field fiber **14** which is inserted into connector **10** is cleaved with a good end face, preferably with a cleave angle less than about 1 degree, to facilitate transmission therethrough. A light, such as a visible laser light or light from an LED, may be injected in the first end of optical fiber stub **68**, whereupon cam member **30** is turned in a direction which urges splice members **26** and **28** together, thereby securing the abutting ends of optical fiber stub **68** and field fiber **14** in a position that facilitates transmission therethrough. For example, a tool (not shown) may be used to engage with a portion of cam member **30** adapted to engage with the tool, and cam member **30** then rotated to urge splice members **26** and **28** together. View port **78** may then be observed for an indication of the quality of the splice between the optical fiber stub **68** and field fiber **14**, as described supra. When cam member **30** has been rotated and a good splice indicated by the absence of light from view port **78**, trigger member **142** may then be snapped onto cam member **30** as previously described.

[0067] As described above, an optical fiber connector **10** of the present invention can be readily fabricated. In particular, the ferrule can be formed and the optical fiber stub **68** disposed therein in a factory setting such that the first end of the optical fiber stub **68** can be polished while disposed in the first end of ferrule **18**. Thereafter, an end portion of a second optical fiber, such as field fiber **14**, can be inserted through lead in tube **84** into cavity **70** between splice members **26, 28**, whereupon cam member **30** may be rotated to activate splice members **26, 28**. When activated, splice members **26** and **28** secure the

second end **69** of optical fiber stub **68** and field fiber **14** to facilitate transmission therethrough. Once optical fiber stub **68** and field fiber **14** have been secured by splice members **26**, **28**, the various remaining components of connector **10**, such as crimp band **134** and boot **138**, may be assembled onto fiber optic connector **10**.

[0068] It will be apparent to those skilled in the art that various modifications and variations can be made to the present invention without departing from the spirit and scope of the invention. Thus it is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.